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(71) Applicant: Spectra-Physics Inc.
3333 North First Street
San Jose California 95134-1995(US)

(72) Inventor: Rando, Joseph F.
13838 Templeton Place
Los Altos Hills, California(US)

(74) Representative: Jones, Ian et al
POLLAK MERCER & TENCH High Holborn
House 52-54 High Holborn
London WC1V 6RY(GB)

(54) Method and apparatus for surface marking.

(57) The invention provides for the marking of surfaces, for example, those of glass laboratory vials, which are marked by removing surface material therefrom. The vial (24) is moved relative to material removal means, for example a grinding wheel (10), under the control of a computer (50) so as to grind a desired bar code or alphanumeric symbols into the vial surface 24B. The ground portion of the vial surface 24B scatters light while the unground portion of the surface transmits light, the ground pattern can thus be read by optical reading means, for example bar code reading means. The process may be automated and performed by a robot as part of an analyzing or processing system.

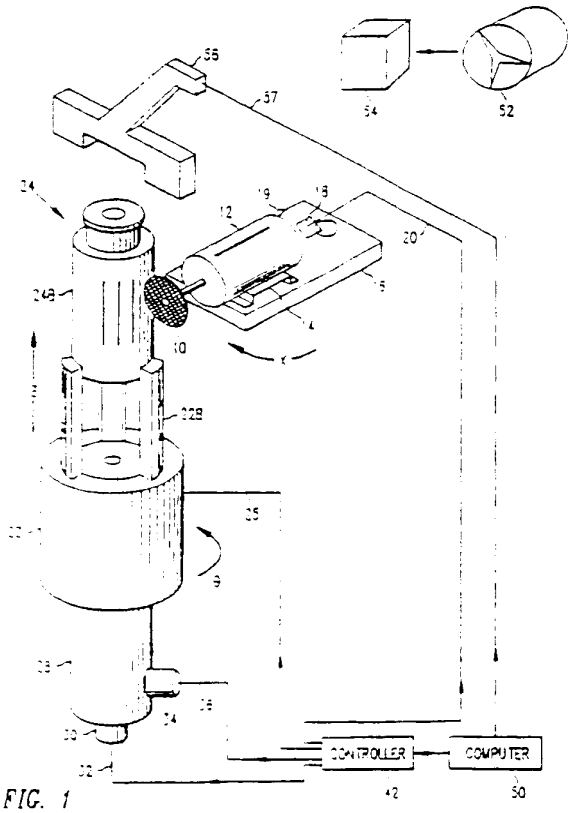

FIG. 1

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METHOD AND APPARATUS FOR SURFACE MARKING

The present invention relates to a method and apparatus for surface marking, and in particular, but not exclusively, to a method and apparatus for forming bar code markings on the surface of a transparent container as part of an integrated handling system.

It is well known to mark the surfaces of objects such as glass containers by molding, inscribing, etching or otherwise altering the surface of the object. It is also known to imprint marks on the surface of an object, for instance as described in U.S. Patent No. 4 810 867. This document discloses a method of imprinting bar codes on a surface using an imprinting device which imprints a matrix of dots on the surface of an object which is attached to a table assembly. The disclosed method is typical of dot matrix imprinting methods and is not suitable for marking brittle materials such as glass. Also, such known methods are typically most useful for marking the surface of flat items which can be readily attached to a support table.

In many laboratory applications, glass or plastic vials or test tubes are marked either with a conventional bar code - to allow automated reading - or with alphanumeric markings to identify the contents. Typically, paper labels having printed markings are glued to a surface of the vial. This method is disadvantageous because the labels tend to come off when exposed to liquids or chemicals, so that the information on the label is lost. Also, any surplus adhesive on the label can obstruct the mechanisms of automatic handling devices commonly used as part of an automated laboratory system. Also, heat can destroy the glue holding the labels on, causing the labels to fall off, which restricts the type of environment in which the vials can be used.

In addition, the paper labels must be glued on manually, which prevents full automation of the process of handling and marking the vial. The paper labels can also obstruct or prevent viewing the contents of the vial.

In accordance with a first aspect of the invention there is provided a method of marking a surface of a member characterised by removing surface material from the surface by way of material removal means and moving the removal means relative to the surface to mark a predetermined pattern on the surface.

In accordance with another aspect of the present invention, there is provided surface marking apparatus characterised by means for supporting a member which includes the surface to be marked, means for removing material from the surface so as to mark the same, and means for moving the removing means relative to the surface to mark a predetermined pattern on the surface.

The marks may make up a bar code or any other required pattern.

Preferably, the marks are ground in the surface by an abrasive wheel; the object being moved relative to the wheel so as to grind in the desired markings. The ground portion of the surface of the object scatters light while the unground portion of the surface transmits light. Thus, when the desired marking comprises a bar code, the ground areas form the conventionally "white" i.e., reflective background areas of the bar code, and the unground areas, which do not reflect light, are the conventionally "black" non-reflective bars of the bar code.

This process may be automated or carried out under manual control. The process has advantages over the known art in that it is suitable for use for marking rather brittle and fragile glass typically used for laboratory containers. In particular, the invention allows for ready viewing of the vial contents. Also, markings are advantageously resistant to the effects of head, chemicals, water, etc., and also eliminate the need for adhesives or paper labels.

The present invention seeks to overcome the disadvantages of the known art in providing a method and apparatus for forming a durable mark on the surface of an object. In particular the invention seeks to provide a method and apparatus for marking the surface of objects as part of an overall analyzing and chemical processing system. Also, the invention seeks to provide a method and apparatus for bar code marking the surface of a transparent object where the marked areas correspond to the "white" reflective bars of the bar code, and the unmarked areas correspond to the non-reflective "dark: bars of the bar code.

The invention is described further hereinafter, by way of example only, with reference to the accompanying drawings, in which:

Fig. 1 illustrates surface marking apparatus embodying the invention; and

Fig. 2 is a block diagram illustrating a method of surface marking embodying the invention.

An apparatus as shown in Fig. 1 is provided to grind markings into glass (or plastic or similar material) laboratory vials or test tubes or other objects. A diamond grinding wheel 10, of the type commercially available from Marsnall Laboratories, is provided having a diameter of 1 inch (2.54cm) and a thickness of .006 inches (.15mm). The typical minimum width of a bar code line is .008 inches (.2mm) so the thickness of the grinding wheel 10 is more than adequate for grinding bar code mar-

kings. A thicker wheel having a thickness of .008 inches (.2mm) may also be used to grind thicker lines. The dimensions of the grinding wheel are not critical to the invention. Other grinding wheels, such as carborundum or silicon carbide wheels may also be used. The grinding wheel 10 is mounted on a shaft of a conventional, small, high-speed electric motor 12, preferably capable of at least 3,000 R.P.M.

The motor 12 is mounted on a flexible rectangular mount 14, i.e. a "flexure" which is made of brass and is about .008 inches (.2mm) thick and about 1 inch (2.54cm) high and about 1 inch (2.54cm) wide.

The flexure 14 is fixed to a base member 16. A conventional solenoid 18 is also mounted on the base member 16. The solenoid 18 one such as is commercially available from Ledex, and is mounted on the base member 16 so that when it is energised, by provision of a control signal on a control line 20, the electromagnet (not shown) in the solenoid 18 attracts a steel or iron plunger 19 fastened to the motor 12. Since the motor 12 is mounted on the flexure 14, energising the solenoid 18 pulls the plunger-end of the motor 12 a small distance of about .03 inches (.75mm) and so moves the plunger in the direction "X" as shown. Thus, the motor 12 translates a small distance in direction X under the control of the solenoid 18, which provides the apparatus with one degree of freedom of movement.

A chuck 22 is provided in close proximity to the grinding wheel 10. The chuck 22 comprises a conventional three-jawed chuck similar in configuration to that used in machine tools. The chuck 22 is of a type suitable to grip a glass laboratory vial 24 or a test tube; a typical vial 24 is 1cm to 3cm in diameter. The chuck 22 also comprises a conventional electrically operated chuck having at least two positions, namely, open, when its jaws 22B are open, and closed, when its jaws 22B grip and hold the vial 24. Preferably the chuck 22 has several closed positions, so as to facilitate the gripping of vials of varying sizes. The position of the jaws is determined by electrical control signals provided to chuck 22 by way of a control line 25.

The chuck 22 is mounted on one end of a conventional translation/rotation support means for mechanical stage (i.e. a holder) 28. The mechanical stage 28 has two degrees of freedom. Firstly, it can move up or down along the line of arrow Z relative to the grinding wheel 10, secondly, it can rotate angularly as shown by arrow θ. A conventional stepper motor 30 controls movement along the line of Z under the direction signals provided on control line 32 and a conventional stepper motor 34 controls the rotational movement θ under the direction of control signals provided on control line 36.

Control lines 20, 25, 32 and 36 are all connected to a controller 42. The controller 42 is connected to a host computer or automated laboratory instrument 50. The controller 42 comprises a conventional commercially available microprocessor or a computer.

Also, an exhaust fan 52 is provided in close proximity to the grinding wheel 10 which draws air away from the region of the grinding wheel 10 into a container 54 so as to remove debris generated by the grinding. Alternatively, a weak vacuum system (not shown) can draw away the air. A conventional robot arm 56 is provided to place the vial 24 in, and remove it from, the chuck 22. The arm, 56 is controlled by the computer 50 via a control line 57.

The operation of the above-described apparatus is now explained with reference to the block diagram shown in Fig. 2.

The host computer 50 provides a "mark vial" command 50 to the controller 42 and also provides a signal representative of the unique number 64 of the vial 24 which is to be marked on the vial 24. The controller 42 then generates a bar code at step bar code 66 by conventional computer software. A set of corresponding bar code numbers such as the binary string 1001101 is then created at step 66. The controller, by means of computer software, translates this binary string into corresponding X, Z and θ control signals at "generate motion step" 68, respectively for the solenoid 18, the stepper motor 30 and the stepper motor 34.

Upon receiving the mark vial command, the controller 42 issues a command on line 24 to the chuck 22 to open its jaws. At this time, the arm 56 places a vial 24 (taken, for example, from a box of vials, not shown) into the jaws of the chuck 22. After a brief time interval determined by timer software 70, which is part of the software of controller 42, the jaws of the chuck 22 close upon receiving a "chuck close" command on the line 24.

The process of grinding the bar code markings includes the steps of the mechanical stage 28 being moved up in direction Z by the stepper motor 30 until a portion of the surface of vial 24 is in contact with the edge of the grinding wheel 10. [illegible] at, for example, about 3,000 R.P.M.

The controller 42 sends a control signal to the [illegible] on the line 20. This signal energizes [illegible] and pulls the motor 12 in direction [illegible] into the grinding position. The edge [illegible] grinding wheel 10 then grinds a line in the surface 24B of the vial 24. The stepper motor 30 then [illegible] the mechanical stage 28 up slightly (e.g. one step) in direction Z, to extend the line ground in the surface 24B of vial 24. The stepper motor 30 keeps moving the mechanical stage 28, and hence the vial 24 upwards in direc-

tion Z, until one line of a bar code is ground in the vial surface 24B. Preferably, the depth of the line ground in the surface 214B is about .002 inches (.051mm). The relative speed of translation of the vial 24 relative to the grinding wheel 10 is preferably about 2 to 10 inches (5 to 25cm) per second.

If the marking being ground into the surface 24B is a narrow line, then only one pass of the grinding wheel 10 is required to mark a line of sufficient width. If a wider line is desired, as is typically used in certain bar code symbols, then the stepper motor 34 rotates the mechanical stage 28 slightly in direction θ and then the stepper motor 30 moves the chuck downward, along the line of Z, as the grinding wheel 10 grinds a second line along the surface 24B parallel to and slightly spaced apart from the first line. If necessary, a third or fourth line can be ground in surface 24B to provide a line of any desired width. A marked bar code is shown on surface 24B.

When one bar code line has been completed, the control signal provided by the controller 42 to the solenoid 18 is terminated, which causes the motor 12 and the grinding wheel 20 to rotate along X, away from surface 24B. Then, by providing a control signal to the stepper motor 34, the controller 42 causes the rotation of the mechanical stage 28 to another position so that the next bar code line can be ground.

This process, as described above, is repeated until a complete bar code symbol is ground into surface 24B. As is evident, any sort of symbol or pattern such as letters or numbers or other markings such as pictures can be ground into surface 24B by suitable control of the solenoid X and the stepper motors 30 and 34. The bar code or other markings can be any desired size, and the width of the ground line and its depth are a function of the material and width of the grinding wheel 10.

During the grinding process, the exhaust fan 52 is operating to pull the dust resulting from the grinding into the container 54, for disposal. After the markings are ground into surface 24B, the mechanical stage 28 moves along Z, downwardly in the drawing, to withdrawn the vial 24 from the vicinity of the grinding wheel 10. Then the jaws of the chuck 22 are opened by a control signal on the line 24. The robot arm 56 grasps the top of the vial 24 and removes it from the chuck 22 and places it in its box (not shown) or in some other location as desired.

As can be appreciated, the above described marking process can be performed on an empty vial or on a vial already containing a sample. The process can be used to inscribe the results of a test on the vial, or merely to number or otherwise mark a vial so as to identify it.

The time to form markings on a vial is relatively brief. A typical bar code .6 inches (1.5cm) high by 1.2 inches (3cm) long takes less than ten seconds of actual grinding time on a glass vial.

In another embodiment, the invention is applicable for forming markings on objects other than vials, such as flat objects.

In yet another embodiment, apparatus other than an abrasive wheel, such as sand blaster, is used to grind the object to be marked. Also, larger or smaller abrasive wheels than that described above may be used.

In a further embodiment, the vial is held stationary and the grinding wheel is moved around the vial.

In yet a further embodiment, the robot arm 56 and/or mechanical stage 28 are omitted, and the operation is performed partially or wholly manually.

In still a further embodiment, after the markings are made, they are verified as being accurate, for instance by way of a conventional bar code reader that automatically reads the markings and verifies that they correspond to the information supplied by the computer 50 as to the pattern to be marked on the vial.

Claims

1. A method of forming markings in the surface of an object comprising the step of removing material from the surface of the object in accordance with instructions as to the markings to be formed so as to form the markings in the surface.

2. A method as claimed in claim 1, wherein means for removing the material and the surface are moved in at least three modes of relative movement.

3. A method as claimed in claim 1 or 2, wherein instructions relating to the markings to be formed are provided by a computer.

4. A method as claimed in claim 3, carried out wholly in response to control signals from a computer.

5. A method as claimed in any one of claims 1 to 4 wherein the material is removed from the surface so as to form a marking pattern comprising a plurality of parallel lines.

6. A method as claimed in any one of claims 1 to 5 wherein portions of the surface from which material is removed are arranged to form light reflecting surfaces.

7. A method as claimed in any preceding claim wherein the material is removed from the surface so as to form a bar code.

8. A method as claimed in any preceding claim, wherein the accuracy of a mark formed in the surface is verified by mark reading means.

9. A method as claimed in claim 8, when

dependent on claim 7, wherein the mark is verified by bar code reading means.

10. A method as claimed in any preceding claim, wherein sand-blasting means are used to remove the surface material.

11. A method as claimed in any of claims 1 to 9, wherein grinding means are used to remove the surface material.

12. A method as claimed in claim 11, wherein the surface is ground by a grinding wheel.

13. A method as claimed in any preceding claim, wherein the object is supported in support means.

14. A method as claimed in any preceding claim, wherein the object comprises a transparent surface.

15. A method of forming a bar-code marking in a transparent surface of a member characterised by grinding a plurality of discrete lines in the surface so as to form discrete light-reflecting lines and discrete non-light-reflecting lines in the spaces between the ground lines.

16. Surface marking apparatus characterised by means for supporting a member which includes the surface to be marked, means for removing material from the surface so as to mark the same, and means for moving the removing means relative to the surface to mark a pattern in the surface.

17. Apparatus as claimed in claim 16, wherein the moving means comprises means for moving the member along a line of movement and means for rotating the member about an axis substantially parallel to said line of movement.

18. Apparatus as claimed in claim 17, wherein the moving means includes means for moving the material removing means a plane substantially perpendicular to the line of movement.

19. Apparatus as claimed in claim 18, wherein the moving means includes a solenoid.

20. Apparatus as claimed in any of claims 16 to 19, including control means for controlling the surface marking in response to control data inout to the control means.

21. Apparatus as claimed in any of claims 16 to 20, wherein the support means is arranged to support a substantially cylindrical member.

22. Apparatus as claimed in any of claims 16 to 21, including means for loading the member in the support means.

23. Apparatus as claimed in any of claims 16 to 22, arranged to mark a bar-code pattern on the surface.

24. Apparatus as claimed in any of claims 16 to 23, including means for verifying the accuracy of the surface markings.

25. Apparatus as claimed in claim 24, when dependent on claim 23, wherein the verification means comprises bar-code reading means.

26. Apparatus as claimed in any of claims 16 to 25, wherein the removing means comprises a motorised grinding wheel.

27. Apparatus as claimed in claim 26, when dependent on claim 21 wherein the support means is arranged to support the member such that the axis of rotation of the grinding wheel is substantially perpendicular to the longitudinal axis of the cylindrical member.

28. Apparatus as claimed in claim 26 or 27, wherein the width of the grinding wheel is less than .008 inches (0.2mm).

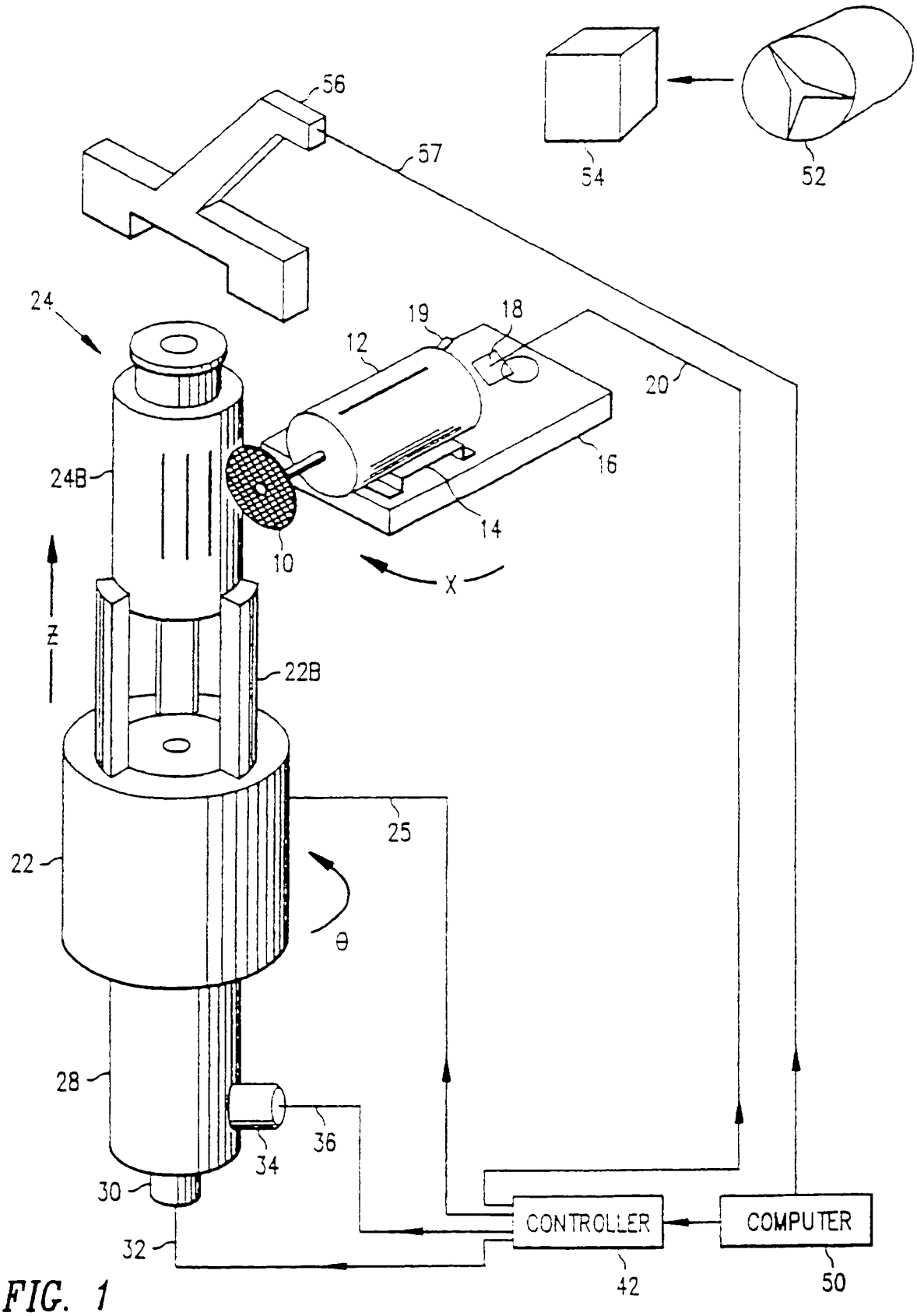
56
57
54
52
24
19
18
12
20
24B
16
14
10
X
Z
22B
25
22
θ
28
36
34
30
32
CONTROLLER
COMPUTER
42
50

FIG. 1

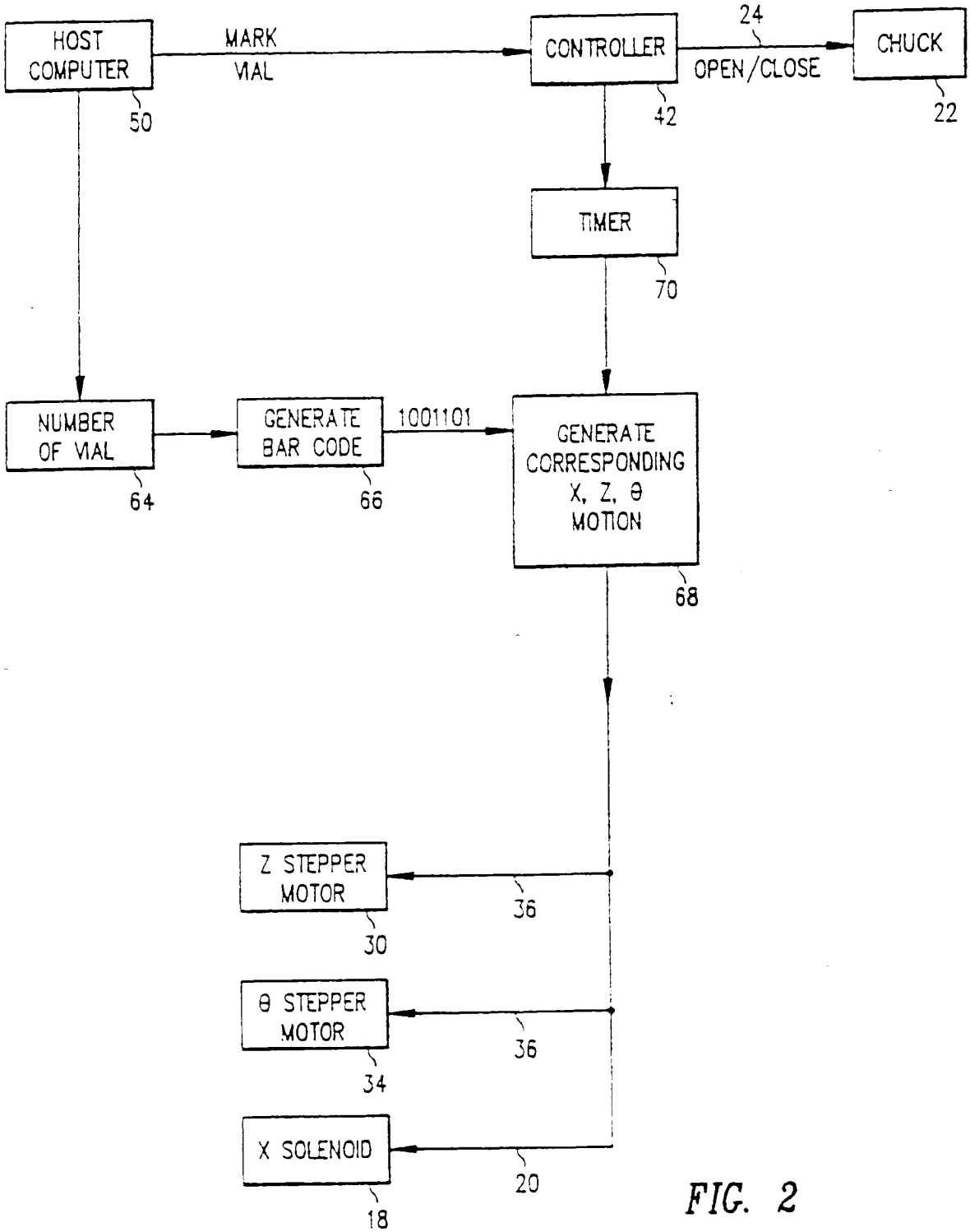
HOST COMPUTER
50
MARK VIAL
CONTROLLER
42
24
OPEN/CLOSE
CHUCK
22
TIMER
70
NUMBER OF VIAL
64
GENERATE BAR CODE
66
1001101
GENERATE CORRESPONDING X, Z, θ MOTION
68
Z STEPPER MOTOR
30
36
θ STEPPER MOTOR
34
36
X SOLENOID
18
20

FIG. 2

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(71) Applicant: Spectra-Physics Inc.
3333 North First Street
San Jose California 95134-1995(US)

(72) Inventor: Rando, Joseph F.
13838 Templeton Place
Los Altos Hills, California(US)

(74) Representative: Jones, Ian et al
POLLAK MERCER & TENCH High Holborn
House 52-54 High Holborn
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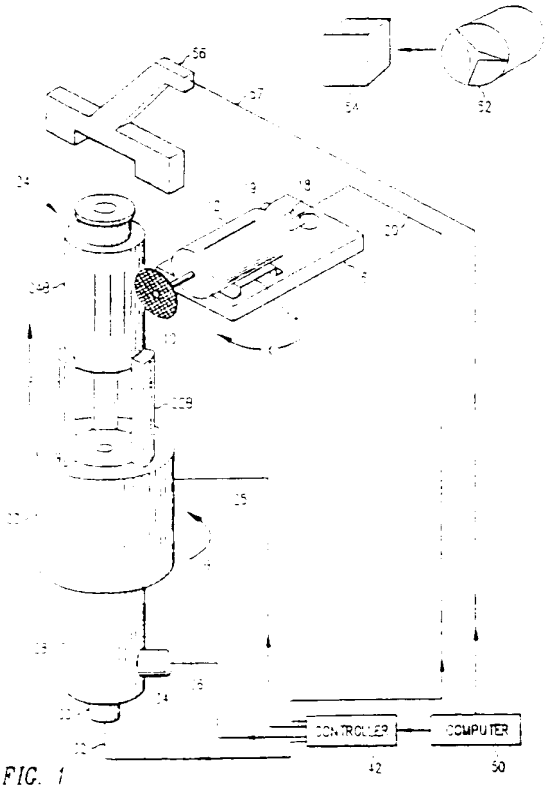

FIG. 1

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European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 90 30 5338

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
X	US-A-4 166 574 (YOKOYAMA) * column 1, line 20 - line 60; claim 1 * * column 12, line 22 - column 3, line 6 * * column 4, line 2 - line 27 *	1-2,6-9, 13,16, 20-25 15 5,17-18, 26,28	G06K1/12 G06K19/06
X	EP-A-0 250 340 (ALUMINIUM PECHINEY) * page 6, line 25 - page 7, line 29; claims 1-11; figures 1-2 * * page 8, line 15 - line 35 *	1-4,8, 13, 16-18, 20,22,24 5,21,26	
Y	WO-A-8 604 878 (THIELMANN-LUMA) * abstract; claims 1-6; figure 2 * * page 1, line 20 - page 8, line 34 *	15 1,16	

TECHNICAL FIELDS SEARCHED (Int. Cl.5)

G06K

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	29 APRIL 1992	BEAUCE G.Y.G.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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L : document cited for other reasons

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